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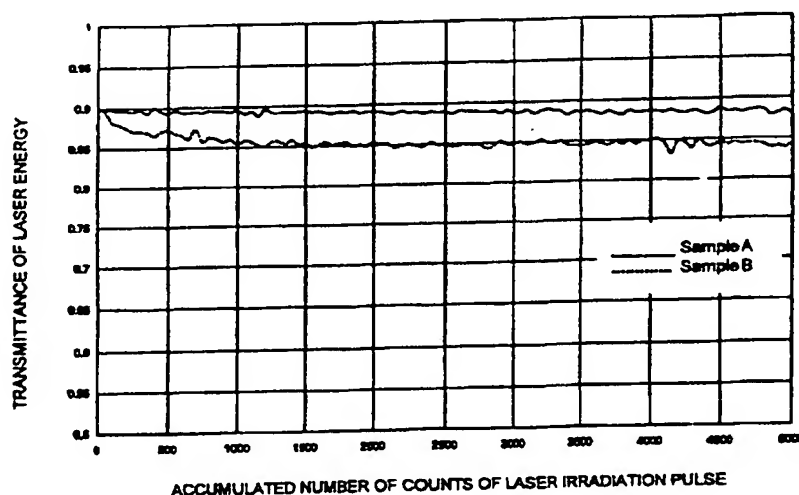
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(57) Abstract

The invention relates to process for producing a quartz glass optical body which is greatly resistive to irradiation of a laser having a short wavelength. According to the invention a quartz glass body is doped with hydrogen during and/or after production of the quartz glass body to a concentration in the range of 2×10^{17} molecules/cm³ to 5×10^{19} molecules/cm³. To eliminate reduction-related defects induced by hydrogen in the bulk, the quartz glass body is irradiated with ultraviolet light of a wavelength in the range 150 nm to 300 nm. By such an irradiation hydrogen-induced defects occurring in production of synthetic quartz glass body by means of an oxyhydrogen flame or formed in a high-temperature hydrogen treatment are eliminated and thereby the quartz glass body is greatly improved in a stability against ultraviolet light. A quartz glass optical body according to the invention is especially suitable for use with an ArF excimer laser of 193 nm in wavelength or a YAG fifth harmonics laser of 213 nm in wavelength.

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**PROCESS FOR PRODUCING QUARTZ GLASS OPTICAL BODY
FOR ULTRAVIOLET-EMITTING LASERS
AND QUARTZ GLASS BODY PRODUCED ACCORDING TO THE PROCESS**

Detailed Description of the Invention

Industrial Field and Prior Art

The present invention relates to a method of producing a synthetic quartz glass optical body for using with an ultraviolet laser, and more particularly it relates to a quartz glass optical glass body which is a suitable optical member for the use of constructing an optical system using an high energy ultraviolet laser as a light source.

In recent years in the photolithographic technology optical systems such as aligners are used which are capable of patterning with a line width in a submicron range. In order to permit even a finer line width new light sources having shorter wavelengths must be used for the optical systems.

For example, the conventional light sources for a stepper work with light of the so-called "g line" (436 nm in wavelength) or "i line" (365 nm in wavelength). Meanwhile KrF excimer lasers are used having a wavelength of 248 nm. During the next developments KrF excimer lasers will be replaced by ArF excimer lasers having a wavelength of 193 nm or by YAG fifth harmonics lasers having a wavelength of 213 nm.

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However the quartz glass is subject to structural damages in a long run of irradiation with such deep UV-light. Moreover the excimer laser light is emitted as a pulse having a short life time or a pulse duration in the order of 20 ns. Therefore energy of such a light has a very high density compared with that of the ultraviolet light emitted from an ordinary mercury lamp or like that. Therefore the energy load imposed on the quartz glass becomes extremely large.

In order to overcome such problems it was suggested to use for such purposes a synthetic quartz glass member free of striae in at least one direction, having an hydroxyl group concentration of at least about 100 wt-ppm and a hydrogen concentration of 5×10^{16} molecules/cm³ or more (U.S. Patent No. 5,086,352).

Problem the Invention Seeks to Solve

As mentioned above, a shift from a KrF excimer laser of 248 nm in wavelength to an ArF excimer laser of 193 nm in wavelength and the YAG fifth harmonics laser of 213 nm in wavelength, which are shorter than that of the KrF excimer laser, is occurring in the latest development of photolithographic technology for LSI fabrication.

Such new laser light sources are apt to bring about undesirably larger damages than those occurred by the conventional light sources in the bulk of a quartz glass body, since they have a shorter wavelength compared with that of a KrF excimer laser light and thereby the energy of the light is larger too. In order to cope with this difficulty in the use of the ArF excimer laser or the YAG fifth harmonics laser, both having high energy, an ample laser resistance may be assumed by doping the quartz glass with hydrogen at a higher concentration.

However, as disclosed in a publication of Unexamined Japanese Patent Application No. Hei 6-166528, a reduction-related defect arises in the bulk of a synthetic quartz glass body by hydrogen incorporated during production of the quartz glass body or by hydrogen doped in a process at a temperature of 600°C or higher after the production. This reduction-related defect brings about a paramagnetic defect called E* center which shows an absorption at a wavelength of 215 nm. The absorption begins immediately after the initiation of radiation of an excimer laser. Therefore, doping the quartz glass body with hydrogen during the production of synthetic quartz glass is not suitable.

The E* center is no problem in the case where a KrF laser is used, since light of the laser has a long wavelength, but in the case where an ArF excimer laser of 193 nm in wavelength or a

fivefold harmonics of a YAG laser is used, the paramagnetic defect which is called E* center becomes problematic.

In order to remove such a reduction-related defect induced by incorporated hydrogen in the bulk of a starting mother body, a method is proposed in a publication of Unexamined Japanese Patent Application No. Hei 6-166528, which comprises the steps of: treating a quartz glass body in a heating process at a temperature of 1500°C or lower in an oxidizing atmosphere; and doping the quartz glass body with hydrogen at a temperature of 600°C or lower, or preferably 400°C or lower.

However, it is very time consuming and thereby inefficient to dope a quartz glass body with hydrogen to a very high concentration at such a low temperature as 600°C or lower.

It is therefore an object of the present invention to provide a method of producing a quartz glass optical body for an ultraviolet laser wherein a hydrogen-induced reduction-related defect is eliminated in the bulk of a quartz glass body, even when hydrogen is doped into the bulk at a temperature of 400°C or higher.

It is another object of the present invention to provide a synthetic quartz glass optical body for use with an ultraviolet laser, in whose bulk hydrogen-induced defects are eliminated, and which has an excellent stability against ultraviolet light, especially against an ArF excimer laser of 193 nm in wavelength or against a YAG fifth harmonics laser of 213 nm in wavelength.

Means to Solve the Problem

It was found that the above mentioned object was achieved by a method of producing a quartz glass optical body comprising

- a) incorporating hydrogen into a synthetic quartz glass body at a concentration in the range of 2×10^{17} molecules/cm³ to 5×10^{19} molecules/cm³,
- b) irradiating the quartz glass body using ultraviolet light of a wavelength in the range of 150 nm to 300 nm at a illuminance of 1 mW/cm² to 100 W/cm² for a period of time of 20 h or longer.

By that a hydrogen-induced defect being brought about in a hydrogen treatment during production of a synthetic quartz glass or in a hydrogen treatment at high temperature was

selectively destroyed and eliminated without no influence on the structure of a quartz glass body.

More particularly, it was found that such a "pre-irradiating" using ultraviolet light of a continuous wave had a energy density per a unit time lower than ultraviolet laser light emitted as pulses. Therefore it was effective for elimination of reduction-related defects but not for the destruction of the structure of the quartz glass body. Even with such ultraviolet light of a continuous wave, however, when an irradiating energy density was larger beyond 100 W/cm^2 , it was found that some quartz glass had a chance to receive structural damages.

Working at the limits of the above mentioned ranges however was found to be acceptable. The reason why a concentration of hydrogen doped in the bulk of the quartz glass body is restricted to an upper limit of $5 \times 10^{19} \text{ molecules/cm}^3$ is that at higher concentrations the hydrogen-induced, reduction-related defects cannot be eliminated enough only by irradiation. Therefore for some purposes an upper hydrogen limit of $2 \times 10^{19} \text{ molecules/cm}^3$ is more suitable.

There is no definition of the upper limit for a period of the radiation step, which is longer than 20 h. The upper limit should be determined according to the number and property of reduction-related defects present in the bulk but there arises no problem with longer period irradiation, since the longer period irradiation is harmless in regard to a question of whether or not the structure of the quartz glass body is destroyed.

In a first aspect the quartz glass optical body which is greatly resistive to irradiation of laser light of a short wavelength such as light of an ArF excimer laser or a YAG fifth harmonics laser is produced, by incorporating of hydrogen into the synthetic quartz glass body comprising

- a) a first incorporating of hydrogen during the production of the synthetic quartz glass from which the quartz glass body is made, and/or
- b) a second incorporating of hydrogen into the quartz glass after or during a homogenization process of the synthetic quartz glass, which results in a doping with hydrogen to a concentration in the range of $2 \times 10^{17} \text{ molecules/cm}^3$ to $2 \times 10^{19} \text{ molecules/cm}^3$.

The incorporation of hydrogen is conducted in a step in which the quartz glass body is produced and/or in a later step in which hydrogen is intentionally doped.

The homogenization process may result in a quartz glass which is free from striae in least one direction. For that purpose a homogenization process may be required including a high

tempearature treatment including a deformation of the quartz glass body. However the homogenization process may also be an annealing process without such a deformation, for example by zone melting. After or during the homogenization process, the quartz glass is doped with hydrogen to a concentration in the range of 2×10^{17} molecules/cm³ to 2×10^{19} molecules/cm³, both limits being included.

In the above case, hydrogen gas is homogeneously doped in the bulk by conducting the homogenization process before the hydrogen doping.

It is reasoned below that also during the production of a quartz glass body, an hydrogen concentration of 1×10^{18} molecules/cm³ or more may be adjusted.

A synthetic quartz glass is produced by means of the direct flame method (which can be simply referred to as the direct method) categorized in the oxyhydrogen flame hydrolysis method or the CVD soot remelting method (which can be simply referred to as the soot method). If the synthetic quartz glass body is produced in an excessive oxygen contained atmosphere, essentially no hydrogen is incorporated into the bulk and to be exact, hydrogen is incorporated at a concentration of 5×10^{16} molecules/cm³ or less.

If a synthetic quartz glass body is doped with hydrogen in a condition that the quartz glass body has essentially no hydrogen incorporated therein, it is difficult to dope the quartz glass body with hydrogen to a concentration in the defined range above with a homogeneity enough for the practical purpose in the case where the quartz glass body is a large optical member such as a lens for a photolithographic use, since there is difficulties relating to a diffusion velocity of hydrogen and the like.

Therefore, to achieve a homogeneously doping of the synthetic quartz glass body with hydrogen to a concentration in the range defined above it is preferred that the hydrogen is homogeneously dispersed in the quartz glass during production thereof at a concentration of 1×10^{18} molecules/cm³ or more. The production of the synthetic quartz glass is conducted in a reductive atmosphere rich in hydrogen.

However, if hydrogen is incorporated in the bulk at a concentration in the above defined range, some or even the most of the incorporated hydrogen molecules may diffuse out of the bulk during a subsequent homogenization process. Such a homogenization process may be a high tempearature treatment including a deformation of the quartz glass body; it may also be an annealing process without such a deformation, for example by zone melting.

- Therefore according to the second aspect of the present invention, doping the quartz glass body with hydrogen is conducted separately in a process after the homogenization process, or simultaneously to the homogenization process. Such a doping may serve not only to supplement the hydrogen diffused out of the quartz glass during homogenization, but also to disperse uniformly the doped hydrogen throughout the bulk.

In the most preferred embodiment a combination of the incorporation of hydrogen during production of the synthetic quartz glass body, and hydrogen doping after or during the homogenization process.

An example for hydrogen doping during the homogenization process may be an annealing process in a hydrogen atmosphere in order to suppress the outdiffusion of hydrogen having been incorporated in the bulk of quartz glass body during its production, and in order to adjust a concentration of hydrogen in the bulk in the range of 2×10^{17} molecules/cm³ to 5×10^{19} molecules/cm³.

A third aspect of the present invention is directed to a method of producing a quartz glass optical body for an ultraviolet laser, wherein the hydrogen doping during or after the homogenization process is conducted at a temperature as high as 400°C to 1200°C, or preferably 600°C to 1200°C.

In the case that the hydrogen doping is conducted at a temperature lower than 400°C, the hydrogen doping is a time consuming process due to extreme slowness of a diffusion velocity. Especially in order to cope with a trend toward a large-sized optical member, there arises a necessity for hydrogen doping at higher temperatures.

At a temperature as high as 600°C or higher, annealing for removal of strains is realized as well as doping of hydrogen. Thereby it is possible to achieve a homogeneity of refractive index distribution within the range of $\Delta n < 2 \times 10^{-6}$ as well as a radiation resistance of a quartz glass optical body with a great effectiveness.

Preferably the concentration of hydrogen in the quartz glass body directly before the hydrogen doping is adjusted at concentration in the range of 1×10^{17} molecules/cm³ or more.

Ultraviolet light for the irradiation step is preferably one of 184.9 nm and/or 253.7 nm in wavelength emitted from a low pressure mercury lamp or one having a continuous spectrum between wavelengths of 150 nm and 300 nm emitted from a xenon lamp or a deuterium lamp.

A further aspect of the present invention relates particularly to the so-called direct flame method for producing a quartz glass body. Fine silica particles are formed by flame hydrolysis in a reductive oxyhydrogen flame and they are piled up on a rotating substrate and at the same time, are molten to form the quartz glass body, the quartz glass body is treated in a homogenization process, and after or during the homogenization process, doping with hydrogen is adjusted a concentration of hydrogen in the quartz glass body in the range of 2×10^{17} molecules/cm³ to 5×10^{19} molecules/cm³.

Another aspect of the present invention is directed to a method of producing a quartz glass optical body produced by the so-called CVD-soot-method. A porous silica mother body (soot) is produced by piling up fine silica particles on a rotating substrate, said particles being formed by flame hydrolysis of a volatile silicon compound in an oxyhydrogen flame, the porous silica mother body is transformed into a transparent quartz glass body in a hydrogen contained atmosphere; then the quartz glass body is treated in a homogenization process and after or during the homogenization process, hydrogen doping is conducted to adjust a concentration of hydrogen in the quartz glass body in the range of 2×10^{17} /cm³ to 5×10^{19} molecules/cm³.

Therefore, the present invention is applied to synthetic quartz glass bodies respectively produced by means of the direct flame method and the CVD soot remelting method.

Embodiments of the Invention

Embodiments of the present invention will be described in reference to the accompanying drawings. It is to be expressly understood that temperatures, pressures, materials, periods of time all described in embodiments, and production methods in conditions of the just mentioned parameters also described therein are not intended as a definition of the limits of the present invention, unless a special note is otherwise stated.

- FIG. 1** is a graph showing change in transmittance in the bulk of Samples A and B when irradiated by ArF laser light.
- FIG. 2** is a graph showing change in transmittance in the bulk of Samples C and D when irradiated by ArF laser light.
- FIG. 3** is a graph showing change in transmittance in the bulk of Samples E and F when irradiated by ArF laser light.
- FIG. 4** is a schematic view of a homogenization apparatus used for the homogenization of the samples.

Example 1

First of all, a method of producing a synthetic quartz glass body used in embodiments of the present invention will be described.

Volatile silicon compounds used for synthesis of silica are in general high-purity volatile silicon compounds which are chemically synthesized and purified by means of distillation, for example, silicon halides such as silicon tetrachloride (SiCl_4), alkoxysilanes such as tetraethoxysilane ($\text{Si}(\text{OC}_2\text{H}_5)_4$), tetramethoxysilane ($\text{Si}(\text{OCH}_3)_4$), and alkylalkoxysilanes such as methyltrimethoxysilane ($\text{SiCH}_3(\text{OCH}_3)_3$).

In the example, high-purity methyltrimethoxysilane ($\text{SiCH}_3(\text{OCH}_3)_3$) was used as a volatile silicon compounds for synthesis of a synthetic quartz glass ingot. The synthetic quartz glass ingot of 100 mm in outer diameter and 800 mm long was produced in a so-called direct flame method, wherein the high-purity methyltrimethoxysilane ($\text{SiCH}_3(\text{OCH}_3)_3$) was subjected to flame hydrolysis in a reductive oxyhydrogen flame formed by combusting a stream consisting of a

mixture of oxygen with hydrogen at a ratio of 1 to 5 to produce fine silica particles and the particles were piled up and molted on a rotary substrate.

The OH group concentration in the ingot was measured by a well known conversion equation based on an absorbance at a wave number of 3800 cm^{-1} in the infrared spectrophotometry and the hydrogen molecule concentration was measured by means of the Raman scattering spectrophotometry, wherein measuring devices were Nihon Bunkou Co. made NR-1000 having an Ar laser of an excitation wavelength of 488 nm and an output power of 700 mW as a light source and Hamamatau photonics Co. made R943-02 photomultiplier and measurements were conducted by photon counting.

Measurements of hydrogen molecules in the bulk of the ingot in the example followed a method stated in an article: Zhurnal Prikladnoi Spektroskopii, Vol. 46, No. 6, pp 987 to 991, June 1987. The method is to compare a first absorbance of a Raman band associated with SiO_2 at a wave number of 800 cm^{-1} with a second absorbance associated with a hydrogen molecule at a wave number of 4135 cm^{-1} and to determine a concentration of hydrogen molecules in the quartz glass ingot from the ratio of both absorbances by the use of the following equation (1).

$$C = k(I_{4135}/I_{800}) \quad (1),$$

wherein I_{4135} represents an integrated intensity of a Raman band at a wave number of 4135 cm^{-1} , I_{800} represents an integrated intensity of a Raman band at a wave number of 800 cm^{-1} and k represents a constant being 1.22×10^{21} .

The both ends of a synthetic quartz glass ingot 30 was respectively welded with shank rods 32 having the same diameters as that of the ingot and the welded ingot 30, 32 was further supported rotatably at both furthest ends with chucks 31 of a homogenization apparatus shown in FIG. 4. With the both chucks 31 rotated in the same directions in a synchronizing manner with each other, the synthetic glass ingot 30 was rotated reciprocally between the extremes in a given angular distance together with the chucks 31 and during the rotation of the ingot, one end thereof was heated till a melt zone was formed by the heating of an oxyhydrogen flame burner 34. After formation of the melt zone 30a, both chucks 31 were rotated in opposed directions to confer a force to blend in a peripheral direction on quartz glass in the melt zone 30a. Motors 35 was mounted in the apparatus for rotating the chucks 31 in either the same directions or opposed directions, or reciprocally in both directions at the initial stage.

Next, the oxyhydrogen burner 34 was slowly translated relatively toward the other end of the synthetic quartz glass ingot 30 to thereby homogenize the whole body of the same ingot.

After completion of the homogenization process, the shank rods 32 were cut off the synthetic quartz glass ingot 30 and a sample piece was taken by slicing from the ingot 30 to observe striae. Some striae were found when the ingot was seen in a direction perpendicular to the rotation axis of the ingot 30, but no stria was found when it was seen in the direction of the rotation axis.

After the homogenization process, the synthetic quartz glass ingot 30 was transformed into a disk of 200 mm x 100 mm in diameter by the use of a graphite mold at a high temperature of 1800°C or higher in a nitrogen atmosphere. After taken out from the mold, the disk was held at 1150°C for 40 h in the atmospheric air and subsequently was cooled at a rate of -5°C/h to finally obtain a quartz glass optical body with high homogeneity, said optical body having no stria in one direction and a homogeneity in refractive index distribution of a Δn of 1×10^{-6} across a plane orthogonal with an incident ray at a wavelength of 633 nm. The concentration of hydrogen molecules incorporated in the quartz glass optical body thus obtained was measured at 5×10^{17} molecules/cm³ by means of the Raman scattering spectrophotometry as described above.

Two samples having dimensions of 30 x 30 x 50 mm³, were cut from the quartz glass optical body and the six faces of each were mirror-polished. One sample was radiated at a illuminance of 480 mm/cm² by continuous-wave beams of 184.37 nm and 253.7 nm in wavelength emitted from a low pressure mercury lamp for a period of time of 2 weeks (hereinafter referred to as Sample A). The other sample was not radiated at this point of time (hereinafter referred to as Sample B).

Then Samples A and B were irradiated by an ArF excimer laser having an output power of 5 W with an energy density per pulse of 50 mJ/cm² x pulse and a frequency of 100 Hz to measure change in transmittance with respect to an accumulated number of pulse counts. It was recognized from the measurements that Sample B showed reduction in transmittance immediately after initiation of irradiation, but Sample A showed almost no reduction in transmittance in the course of the measurement.

Example 2

In the similar manner to the above, high-purity methyltrimethoxysilane was subjected to flame hydrolysis in a reductive oxyhydrogen flame formed by combusting a stream consisting of a mixture of oxygen with hydrogen at a ratio of 1 to 3 to produce fine silica particles and the particles were piled up and molten on a rotary substrate.

The concentration of hydrogen incorporated in the synthetic quartz glass ingot was measured at 4×10^{17} molecules/cm³ by means of the Raman scattering spectrophotometry.

Next, the quartz glass ingot was held in the homogenization apparatus shown in FIG. 4 and homogenized in one direction by means of the zone melting method still in the same apparatus and then transformed in the mold into a disk of 200 x 100 in diameter at a temperature of 1800°C or higher in a nitrogen atmosphere. After taken out of the mold, the quartz glass disk was cooled at a rate of -5°C/h to obtain a quartz glass optical body of high homogeneity, which has a homogeneity of refractive index distribution (Δn) across a plane orthogonal with an incident ray $\Delta n = 1 \times 10^{-5}$ at a wavelength of 633 nm. The concentration of hydrogen molecules in the quartz glass optical body was measured at 1×10^{17} molecules/cm³ by means of the Raman scattering spectrophotometry.

Five block-like samples having dimensions of 30 x 30 x 50 mm³, were cut from the quartz glass optical body and the six faces of each were mirror-polished. One sample was irradiated at a illuminance of 480 mm/cm² by continuous-wave beams of 184.37 nm and 253.7 nm in wavelength emitted from a low pressure mercury lamp for a period of time of 2 weeks (hereinafter referred to as Sample C). The rest of samples were not radiated at this point of time.

Two other Samples were then doped with hydrogen in a hydrogen atmosphere of a pressure of 2 kg/cm² at 1000°C for 8 h. In both samples the concentration of hydrogen was 5×10^{17} molecules/cm³. One of these two other samples was further exposed to ultraviolet light in the same conditions as Sample A (hereinafter respectively referred to as Sample E and Sample F), wherein the last Sample without no exposure to all the irradiations above was hereinafter referred to as Sample D.

All samples were exposed to radiation of light from the ArF excimer laser in the same conditions as those of Example 1 to measure the change in transmittance.

Next, a sixth mirror-polished sample was sealed into a furnace with a hydrogen gas as a atmosphere at a pressure as high as about 50 Pa therein and doped with hydrogen in conditions of 50 kgf/cm², 600°C and 720 h. The concentration of hydrogen molecules incorporated in the sample was 5×10^{19} molecules/cm³.

The sixth sample was then exposed to ultraviolet light in conditions similar to those of Example 1 (hereinafter referred to as Sample J). Sample J was exposed to irradiation of light from the ArF excimer laser in the same conditions as those of Example 1 to measure the change in transmittance.

According to measurement of transmittance of laser energy shown in FIG. 2, it was recognized that Sample D showed a reduction in transmittance immediately after initiation of radiation, but Sample C showed no reduction in the course of the measurement. According to the measurement shown in FIG. 3, it was recognized that Sample F showed a reduction in transmittance immediately after initiation of radiation, but Sample F showed no reduction in transmittance in the course of the measurement. It was recognized that Sample J showed a reduction in transmission (not illustrated in a graph) which reduction is not so high as those of Samples D, F.

Example 3

Silicon tetrachloride was subjected to flame hydrolysis by the oxyhydrogen flame to obtain fine silica particles. The silica particles were piled up on a substrate to form a porous silica mother body, which is called a soot, and the soot was then transformed into a transparent state in a hydrogen-contained helium atmosphere to obtain a silica glass ingot having a hydrogen concentration of 2×10^{18} molecules/cm³.

The silica glass ingot was homogenized, transformed and annealed in the same manner as in Example 1 to produce a quartz glass optical body having a hydrogen molecule concentration of 4×10^{17} molecules/cm³.

Three block-like samples having dimensions of 30 x 30 x 50 mm³ were cut from the quartz glass optical body and the six faces of each were mirror-polished. A first one of the samples was irradiated by continuous-wave light of 184.37 nm and 253.7 nm emitted from the low pressure mercury lamp at a illuminance of 480 mW/cm² for 2 weeks (hereinafter referred to as Sample G). A second one of the samples was irradiated by condensed light from a plurality of

high-powered low pressure mercury lamps at an illumination of 100 W/cm² for 100 h (hereinafter referred to as Sample H), wherein beams from each lamp were condensed by lenses into collective beams stronger in terms of irradiation energy. The last sample was left with no such irradiation as above thereon (hereinafter referred to as Sample I).

The samples were exposed to radiation of light from the ArF excimer laser in the same conditions as those of Example 1 to measure the change in transmittance.

Transmittance of laser energy was measured on the samples (not shown in a graph) and it was recognized from the measurements that Sample H showed a reduction in transmittance before initiation of radiation and Sample G showed a reduction in transmission immediately after the initiation of the radiation, but Sample I showed no reduction or transmission in the course of the measurement.

Effect of the Invention

As described above, according to the present invention, hydrogen-induced defects occurring not only during production of a synthetic quartz glass body by means of oxyhydrogen flame, but also in a hydrogen treatment at high temperature are eliminated and thereby a synthetic quartz glass optical body for an ultraviolet laser which has an excellent stability against ultraviolet light, especially an ArF excimer laser of 193 nm in wavelength or a YAG fifth harmonics laser of 213 nm in wavelength is obtained, and more particularly, hydrogen-induced defects in a quartz glass body can be eliminated with ease even when doping the quartz glass body with hydrogen is conducted at a temperature of 400°C or higher, or preferably 600°C or higher.

**PROCESS FOR PRODUCING QUARTZ GLASS OPTICAL BODY
FOR ULTRAVIOLET-EMITTING LASERS
AND QUARTZ GLASS BODY PRODUCED ACCORDING TO THE PROCESS**

Claims

1. A method of producing a quartz glass optical body for an ultraviolet laser comprising the steps of:
 - a) incorporating hydrogen into a synthetic quartz glass body at a concentration in the range of 2×10^{17} molecules/cm³ to 5×10^{19} molecules/cm³,
 - b) irradiating the quartz glass body using ultraviolet light of a wavelength in the range of 150 nm to 300 nm at a illuminance of 1 mW/cm² to 100 W/cm² for a period of time of 20 h or longer.
2. A method according to claim 1, wherein incorporating of hydrogen into the synthetic quartz glass body comprises:
 - a) a frist incorporating of hydrogen during the production of the synthetic quartz glass from which the quartz glass body is made,
 - b) a second incorporating of hydrogen into the quartz glass after or during a homogenization process of the synthetic quartz glass, which results in a doping with hydrogen to a concentration in the range of 2×10^{17} molecules/cm³ to 5×10^{19} molecules/cm³.

3. A method according to claim 2, wherein during the first incorporating a hydrogen concentration of 1×10^{18} molecules/cm³ or more is adjusted.
4. A method according to claim 2, wherein the doping occurs at a temperature of 400°C to 1200°C, or preferably of 600°C to 1200°C.
5. A method according to claim 1, wherein the ultraviolet light is a light having wavelengths of 184.9 nm and/or 253.7 nm emitted from a low-pressure mercury lamp or a light having a continuous spectrum between wavelengths of 150 nm and 300 nm emitted from a xenon lamp or a deuterium lamp.
6. A method according to claim 1, comprising the steps of producing the quartz glass body by piling up silica fine particles being formed by flame hydrolysis in an oxyhydrogen flame on a rotating substrate, melting the fine silica particles, homogenization of the quartz glass body, and after or during homogenization doping with hydrogen to adjust the concentration of hydrogen in the quartz glass body to a value in the range of 2×10^{17} /cm³ to 5×10^{19} molecules/cm³.
7. A method according to claim 1: comprising the steps of producing a porous silica mother body by piling up silica fine particles being formed by flame hydrolysis of a volatile silicon compound in an oxyhydrogen flame; transforming the porous silica mother body into a transparent quartz glass body by heating in a hydrogen containing atmosphere; homogenization of the quartz glass body, and after or during the homogenization doping with hydrogen to adjust a concentration of hydrogen in the quartz glass body to a value in the range of 2×10^{17} /cm³ to 5×10^{19} molecules/cm³.
8. Quartz glass optical body produced according to one or more of the preceeding claims, designed as an optical member for transmitting radiation of an high energy radiation source as a ArF excimer laser having a wavelength of 193 nm or a YAG fifth harmonics laser having a wavelength of 213 nm.

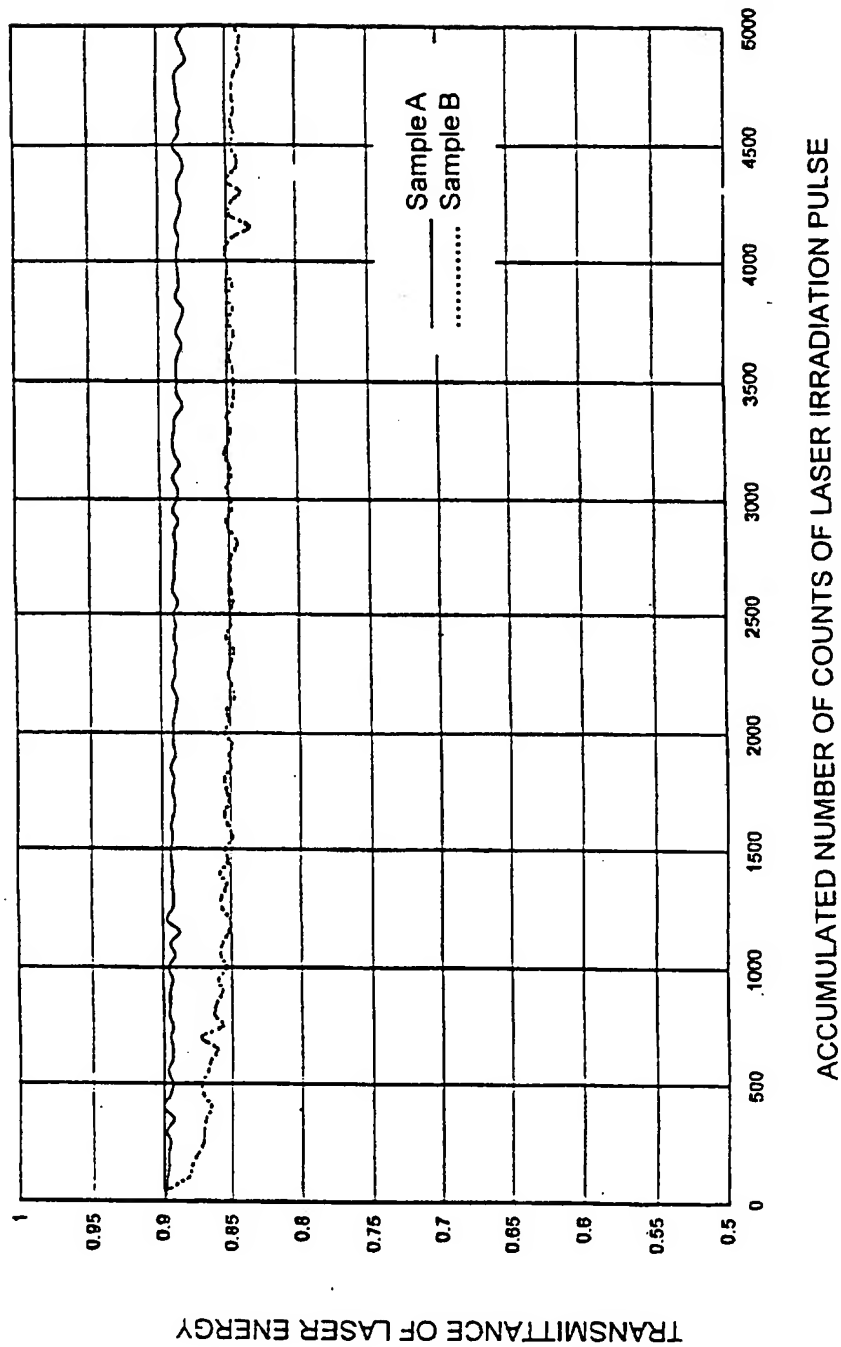


Fig. 1

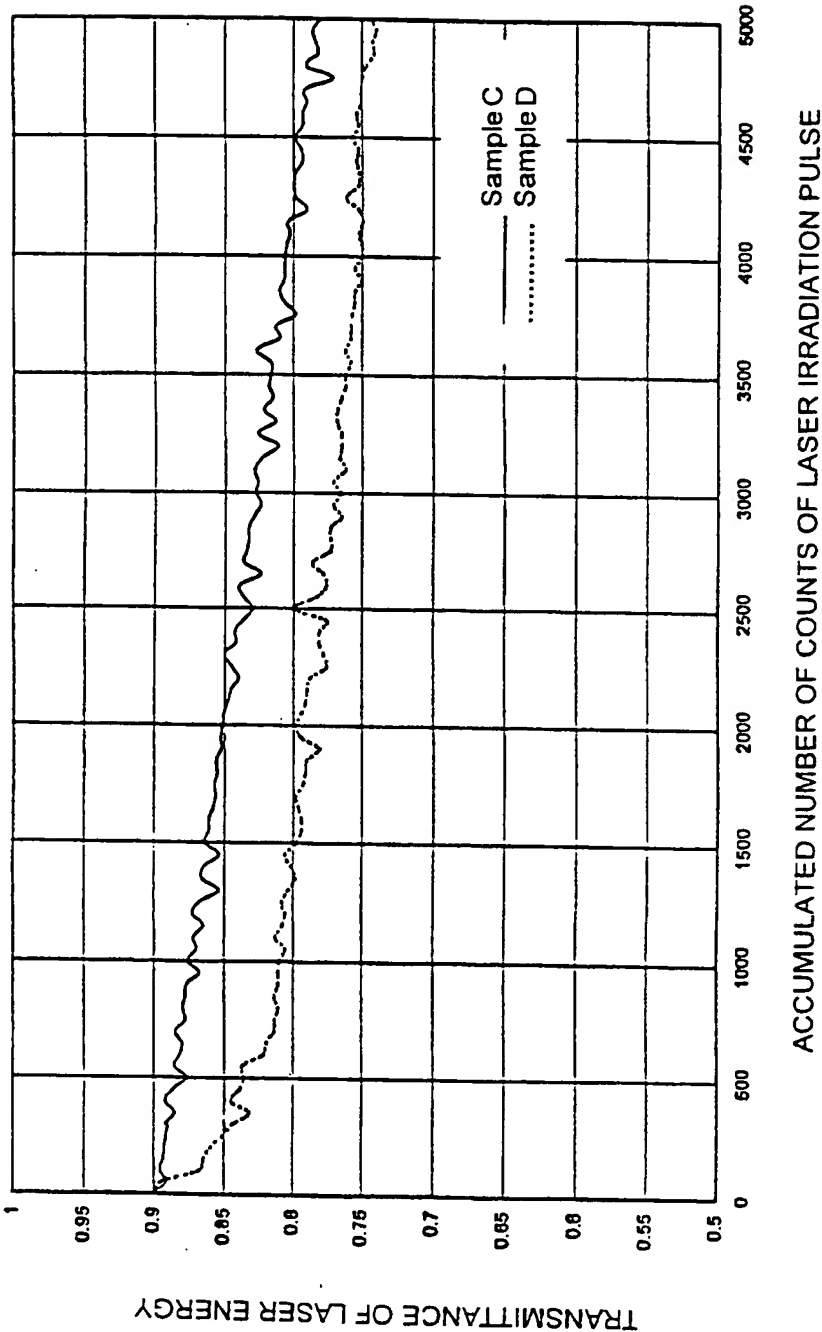
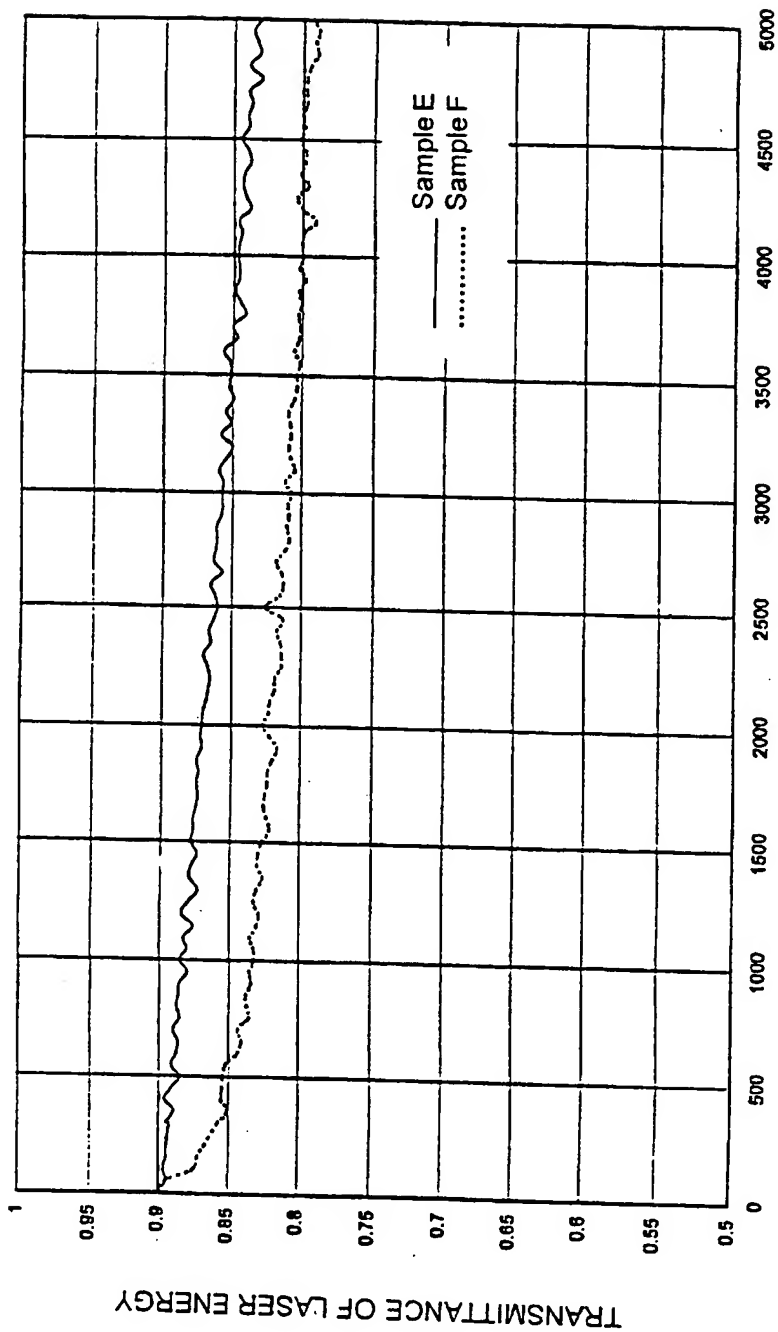


Fig. 2



ACCUMULATED NUMBER OF COUNTS OF LASER IRRADIATION PULSE

Fig. 3

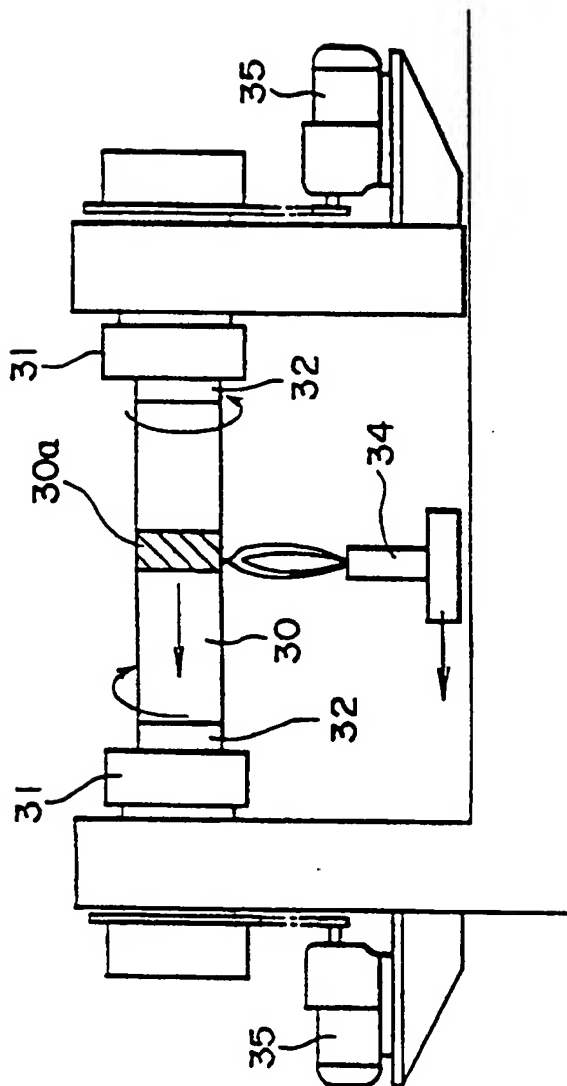


Fig. 4

Internal Application No
PCT/EP 96/04746

IPC 6 C03B19/14 C03B32/00 C03C23/00 G02B1/00 H01S3/034

B. FIELDS SEARCHED

IPC 6 C03B C03C

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP,A,0 483 752 (SHIN-ETSU QUARTZ PRODUCTS CO., LTD. ET AL.) 6 May 1992	8
A	see claims 1,2,14,16,18; examples 1,3,13; table 1	1

X	EP,A,0 401 845 (HERAEUS QUARZGLAS GMBH ET AL.) 12 December 1990	8
	cited in the application	
A	see claims 4,26,28; examples 2,3,7,8,14-16; table 2A	1

A	PATENT ABSTRACTS OF JAPAN vol. 18, no. 495 (C-1250), 16 September 1994	1
	& JP,A,06 166528 (SHIN-ETSU QUARTZ PRODUCTS CO., LTD.), 14 June 1994, cited in the application see abstract	

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☒ Patent family members are listed in annex.

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10 February 1997

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INTERNATIONAL SEARCH REPORT

Interr. Application No.

PCT/EP 96/04746

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>PATENT ABSTRACTS OF JAPAN vol. 11, no. 371 (C-462), 3 December 1987 & JP,A,62 143844 (FURUKAWA ELECTRIC CO., LTD.), 27 June 1987, see abstract</p> <p>-----</p>	1